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(12) # EUROPEAN PATENT APPLICATION

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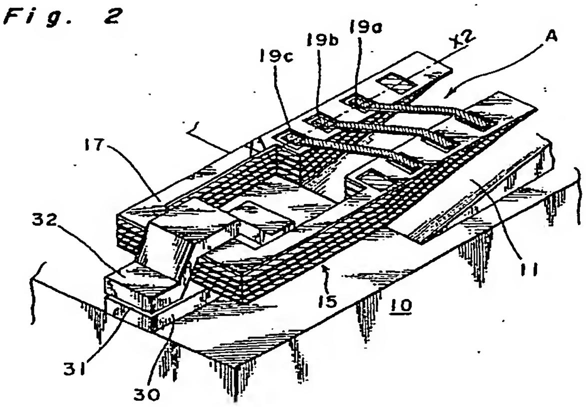
(54) **Method for manufacturing multiturn thin film coil.**

(57) A method for manufacturing a multiturn coil or a film magnetic head including a multiturn coil.

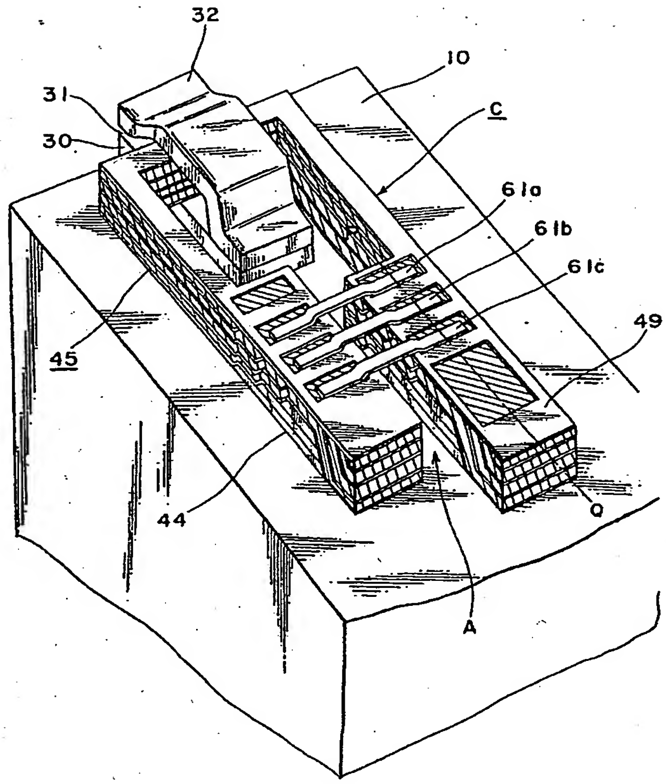
This multiturn coil manufacturing method includes the following steps. First a laminate (15, 45) made up of conducting layers (14a-14d, 47a-47d) for coil and insulating layers (13a-13d, 46a-46d) for coil is formed on a substrate (10) and a base layer (11) formed on it at a given inclination (θ). Then, this laminate (15, 45) is made U-shaped by photolithography. In the next step the topside of the laminate (15, 45) in both discontinued end sections is flattened for the end faces of all conducting layers are revealed at once. Finally, filmy conductive strips (19a-19c, 61a-61c) are formed in these revealed portions to complete a multiturn coil.

Fig. 2



EP 0 402 880 A3

Fig. 4



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EUROPEAN SEARCH REPORT

Application Number

EP 90 11 1142

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	PATENT ABSTRACTS OF JAPAN vol. 6, no. 133 (P-129)(1011) 20 July 1982, & JP-A-57 058217 (HITACHI SEISAKUSHO K.K.) 07 April 1982, * the whole document *	1,2,4	H 01 F 5/00 G 11 B 5/17 G 11 B 5/31
A	US-E-2 932 6 (LAZZARI ET AL.) * column 4, lines 45 - 55; claim 8; figure 4 *	1,4,7,8	
A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 348 (P-519)(2404) 22 November 1986, & JP-A-61 148622 (NIPPON TELEGR & TELEPH CORP		
A	PATENT ABSTRACTS OF JAPAN vol. 5, no. 100 (P-68)(772) 27 June 1981, & JP-A-56 044119 (HITACHI SEISAKUSHO K.K.) 23 April 1981, * the whole document *		
A	GB-A-2 087 656 (ANALOG DEVICES INC.)		TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	WO-A-8 502 479 (MINNESOTA MINING AND MANUFACTURING COMPANY)		G 11 B H 01 F
Y,P,A,P	PATENT ABSTRACTS OF JAPAN vol. 14, no. 183 (P-1035)(4126) 12 April 1990, & JP-A-02 031316 (VICTOR CO OF JAPAN LTD) 01 February 1990, * the whole document *	1,2,4,5-7	

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	20 June 91	FUX J.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
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A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention

E: earlier patent document, but published on, or after the filing date
D: document cited in the application
L: document cited for other reasons

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Fig. 2

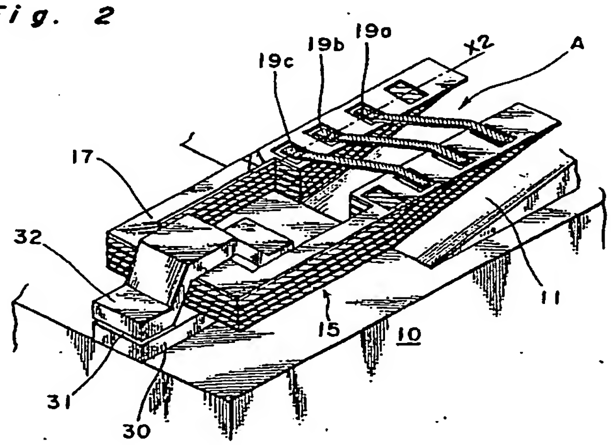
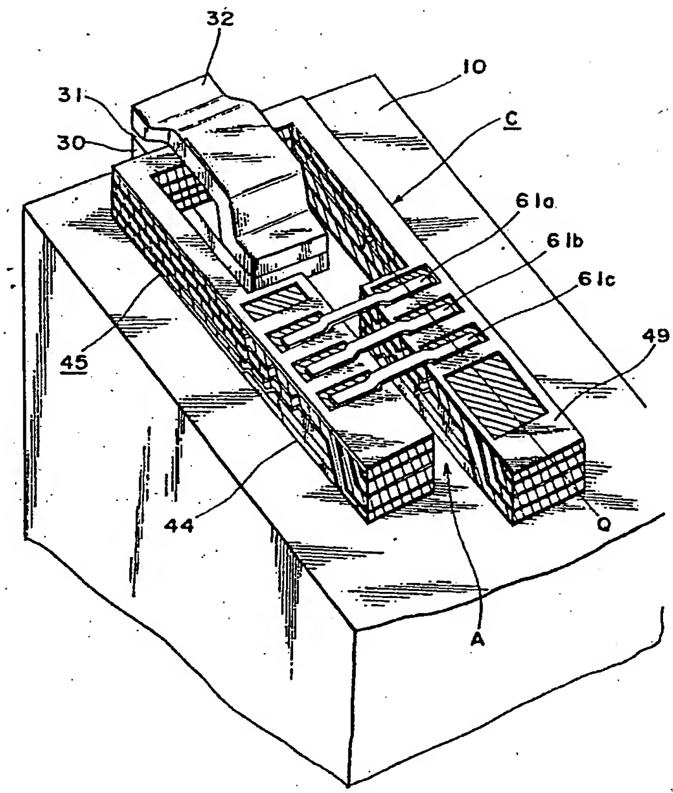


Fig. 4



METHOD FOR MANUFACTURING MULTITURN THIN FILM COIL

BACKGROUND OF THE INVENTION

1. Field of the invention

The present invention relates to a method for manufacturing a multiturn thin film coil preferably adapted to a thin film magnetic head such as a tape drive or the like.

2. Description of the related art

As to the construction of a multiturn thin film coil as a component of such a thin film magnetic head, there are known three alternatives, namely spiral coil 51 as shown in Fig. 1A, zigzag coil 52 as shown in Fig. 1B and helical coil 53 as shown in Fig. 1C and these are already revealed in published literature (IEEE Transactions on Magnetics, Vol. MAG-9 No. 3, page 317). Fig. 1A shows a film magnetic head which includes a magnetic core comprising upper and lower magnetic parts 32 and 30 with a magnetic gap 31 therebetween and a spiral coil 51 arranged on a substrate 10. As shown in the figure, this coil 51 on the substrate 10 has its coiling pattern planar and expanded in X- and Y-directions, thus occupying a large area, hence it is difficult to arrange a plurality of magnetic heads on one substrate 10 at a high density and in parallel across X-direction, this resulting in difficulty of manufacturing a high density multichannel head. Also, the magnetic core is bound to be dimensioned larger in Y-direction with resultant increase of the magnetic path length, this, in turn, resulting in an increased loss of signal fluxes and interfering with the effect of the multiturn coil.

The zigzag coil 52 of Fig. 1B with its smaller dimension in X-direction allows manufacture of a high-density multichannel head, but also has a defect of increased loss of the signal fluxes due to the increase of the magnetic path length of the magnetic core similar to the case of the aforementioned spiral coil.

As a method for eliminating the aforementioned defects proposed is the use of a helical coil 53 shown in Fig. 1C., A conventional method for manufacturing a helical coil comprises the steps of forming a coil conducting film 55, forming an insulating layer 56, forming a through-hole 57 in a coil conducting film 55 and insulating layer 56 and forming a conducting layer for connecting the adjacent coil conducting layer 55 to the through hole 57 layer after layer and to finally complete a multiturn film coil after repetition thereof. Hence, this type of multiturn film coil was complicated in its manufacturing method.

It is therefore, an object of the present invention is to provide a method for manufacturing a thin film multiturn coil featuring the possibility of decreasing the dimensions thereof occupying on the substrate as well as the magnetic path length of a magnetic core and also being simple and easy.

SUMMARY OF THE INVENTION

In accomplishing this object, according to the present invention there is provided an improvement of the manufacturing method of the thin film mutliturn coil comprising the steps of forming a base structure having a substrate and a base layer formed in a given area on a topside of the substrate, the topside of the base layer having a substantially predetermined gradient against the topside of a substrate; forming a loop-shaped laminate on the substrate and the base layer, the laminate comprising a plurality of conducting layers for coil and insulating layers for coil laminated alternately, having a space of discontinuity on the base layer and a part of the laminate on the base layer having substantially the same gradient against another part of the laminate as the base layer against the substrate; removing upper portion of a pair of discontinued end sections of the loop-shaped laminate formed on the base layer so as to reveal an end face of the each conducting layer and the each insulating layer; and mounting electrically conductive members between the revealed end faces of the individual conducting layers in each discontinued end section of the loop-shaped laminate to complete a multiturn coil.

According to the aforementioned manufacturing method of the present invention, the laminate made up of a plurality of conducting layers and insulating layers is made into a coil loop-shaped with a space of discontinuity by, for instance, a photolithographic method. Then by leveling both discontinued end sections of the loop-shaped laminate the revealed end faces of the constituent conducting layers are formed at once, and a multiturn coil is completed by bridging the corresponding pairs of revealed end faces thereof with conductive members.

Hence, unlike in the prior art the photolithographic working may be dispensed with layer by layer. As a result, according to the method of the present invention for manufacturing the multiturn coil for a film magnetic head or the like, the film magnetic head with a high track density and high

efficiency can be manufactured economically with a high yield.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features for the present invention will become apparent from the following description taken in conjunction with the preferred embodiment thereof with reference to the accompanying drawings, in which:

Figs. 1A, 1B, 1C are perspective views showing film magnetic heads using a spiral coil, zigzag coil and helical coil respectively, as described above;

Figs. 2, 2A are a simplified perspective view showing the external appearance of a film magnetic head manufactured by a method including the manufacturing method for a four-turn coil described in a first embodiment of the present invention and a sectional view of a magnetic head in complete form respectively;

Figs. 3I - 3VII are illustratory views successively showing the individual steps of the method for manufacturing the film magnetic head shown in Figs. 2, 2A;

Figs. 4, 4A are a simplified perspective views showing the external appearance of the film magnetic head manufactured by a method including the manufacturing method for a four-turn coil described in a second embodiment of the present invention and a sectional view of the magnetic head in complete form respectively; and

Figs. 5I - 5VIII are illustratory views successively showing the individual steps of the method for manufacturing the film magnetic head described in the second embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

(First embodiment)

Figs. 2, 2A are a perspective view and a sectional view of a four-turn coil type film magnetic head manufactured by a method including the method for manufacturing a multiturn coil described in a preferred embodiment of the present invention respectively. It is to be noted that, as seen from comparison of Fig. 2 with Fig. 2A, Fig. 2 is a simplified view with an insulating layer 16, magnetic gap layer 31 and protective layer 34 omitted. Figs. 3I - 3VII are sectional views taken along the line X1-X2 in Fig. 2 respectively showing the method according to the first embodiment of the present invention.

Referring mainly to Figs. 3I-3VII, steps for the manufacturing method according to this embodiment will hereinafter be described successively.

First a lower magnetic part 30 is formed on a substrate 10 of glass, ceramics or the like by spattering and photolithography (See Fig. 2.).

Then, as shown in Fig. 3I, an insulating base layer 11 of SiO_2 is formed flatly by spattering and then a masking photo-resist layer 12 is formed thereon. Then, as shown in Fig. 3II, the insulating base layer is formed by the well-known ion beam etching method or the like to be sloped at an angle of θ. This angle θ is preferred to be not more than 45°. The reason therefor will be stated later. Thus, the base structure is formed, comprising the sloped insulating base layer 11 on the substrate 10.

In the next step, as shown in Fig. 3III, insulating layers 13a, 13b, 13c, 13d and conducting layers 14a, 14b, 14c, 14d of Cu, Al or the like are alternately laminated by vapor deposition or spattering to form a four-layer laminate 15. Then, the laminate 15 is worked by photolithography to be U-shaped or in loop form with a space of discontinuity A as shown in Fig. 2. As seen from Fig. 3IV, the topside of the laminate 15, the portion thereof lying on the base layer 11, has a gradient substantially the same as that of the base layer 11..

Thereafter, as shown in Fig. 3V, the insulating layer 16 is formed thicker than the insulating base layer 11. The recess inside the U-shaped laminate 15 is filled with the insulating layer 16 (See Fig. 2A.).

In the next step, as shown in Fig. 3V, flattening work is applied to the insulating layer 16 and the laminate 15 by the etch back method (a known flattening technique) utilizing the ion beam etching method or the like or a mechanical grinding method until the insulating layer and the end face of each conducting layer 14a, 14b, 14c, 14d is revealed and the end face becomes substantially parallel to the substrate 10.

Then, as seen from Fig. 3VI, another insulating layer 17 is formed on the flattened laminate 15, insulating layer 16 and base layer 11, and then the insulating layer 17 is partly removed by etching so that connecting terminal parts 18a, 18b, 18c, 18d are revealed.

In the following step, as shown in Fig. 3 VII and Figs. 2, 2A, filmy conductive strips of Cu, Al or the like 19a, 19b, 19c are formed by spattering and photolithography to link the corresponding pairs of the revealed end faces of the individual conducting layers and the pairs of conducting layers 14a, 14b, 14c, 14d thus connected respectively, a four-turn helical coil is completed. The individual filmy conductive strips 19a, 19b, 19c are supported by the insulating layer 16. Alternatively, the conducting layers 14a-14d may as well be connected by bonding with wires instead of the filmy conductive strips

19a-19c.

Although, as mentioned above, the gradient of the sloped base layer is set at not more than 45°, it is thereby possible to form connecting terminal portions X in length of the individual conducting layers 14a, 14b, 14c, 14d not less than "t" in film thickness. When the individual conducting layers and insulating layers constituting the laminate 15 are formed by spattering, vapor deposition or plating, the same mass of the material is deposited per unit surface area parallel to the top surface of the substrate 10. This means that the film thickness "a" in the sloped section of the conducting layer is equal to the thickness "t". Hence, the length X of the connection terminal portion is represented by the following formula.

$X = a/\tan\theta$

$= t/\tan\theta$

hence, when $\theta = 45^\circ$, $X \geq t$ and this means facilitation of connection of the filmy conductive strips 19a, 19b, 19c with the connection terminal portions.

In the next step the insulating layer 16 formed on the magnetic base layer 30, the peripheral part thereof, is partly removed and after forming a magnetic gap layer 31 for formation of a magnetic gap with SiO_2 film as material by spattering and photolithography, a magnetic upper layer 32 is formed on the aforementioned gap layer 31 and then a protective layer 34 is formed to cover the entire structure on the substrate 10.

Then, finally, the contact surface B of the head against a magnetic medium which will advance across the head is finished by grinding to complete a film magnetic head.

(Second embodiment)

Figs. 4, 4A, 5 show the second embodiment of the present invention. Figs. 4, 4A shows the external view and the sectional view of a four-turn film magnetic head manufactured by a method in the second embodiment of the invention including the method for manufacturing a multiturn coil respectively. As in the first embodiment above, Fig. 4 is a simplified view, while Fig. 4A is a sectional view of a complete film magnetic head. Figs. 5I-VIII are sectional views taken along the line P-Q in Fig. 3, showing the method for manufacturing a film coil according to the second embodiment of the invention.

The comprising steps of the manufacturing method in the second embodiment of the invention will be described below successively with reference being made mainly to Figs. 5I-VIII.

First, the magnetic lower layer 30 is formed on the substrate 10 of glass, ceramics or the like (See Fig. 4.).

Then, a copper layer 41, SiO_2 layer and another copper layer 43 are formed successively as shown in Fig. 5I.

As shown in Fig. 5II, these layers are cut by photolithography to form a stepped base layer 44 having substantially a gradient of θ. Thus a base structure comprising a base layer 44 and the substrate 10 is formed.

In the next step, as shown in fig. 5III, insulating layers 46a, 46b, 46c, 46d and conducting layers 47a, 47b, 47c, 47d of Cu, Al or the like are alternatively laminated by vapor deposition or spattering to form a four-layer laminate 45.

In the step shown in Fig. 5IV the aforementioned laminate 45 is cut by photolithography to be in U- shaped as shown in Fig. 4, that is, a loop with a space of discontinuity A.

As shown in Fig. 5V, an insulating layer 48 is formed with a thickness not less than that of the insulating base layer 44. The recess inside the U-shaped laminate 15 is filled with the laminating layer 48 (See Fig. 4A.).

Then, as shown in Fig. 5VI, flattening work is done by the etch back method utilizing the ion beam etching technique or by mechanical grinding until the end faces of the insulating layers 48 as well as conducting layers 47a, 74b, 47c, 47d comprising the laminate 45 are revealed.

In the next step, as shown in Fig. VII, an insulating layer 49 is formed on the flattened laminate 45 and base layer 11 and then the connection terminal portions 60a, 60b, 60c, 60d are revealed by removing the insulating layer 17 by spot etching.

Thereafter, as shown in Fig. 5VIII, filmy conductive strips 61a, 61b, 61c are formed between the revealed portions of the individual conducting layers on both shanks and the conducting layers 47a, 47b, 47c, 47d are connected thereby for a four-turn helical coil to be completed. Then, by making the lengths ℓ_1, ℓ_2, ℓ_3 of the revealed end faces of the individual insulating layers 41, 42, 43 larger than the respective layer thicknesses connection terminal portions whose lengths are not less than the thicknesses of the individual conducting layers 47a, 47b, 47c, 47d can be formed, this facilitating making in a later step of filmy conductive strips 61a, 61b, 61c.

Then the edge portion of an insulating layer 48 formed on the magnetic base layer 30 for formation of the magnetic gap layer 31 for providing a magnetic gap by means of SiO_2 film and, thereafter, the magnetic top layer 32 is formed on the aforementioned gap layer 31 and the protective layer 34 is formed to cover the whole structure on the substrate 10.

Finally, the contact face B of the head against the magnetic medium is finished by grinding or the

like and a film magnetic head is thus completed.

Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

Claims

1. A method for manufacturing a thin film multiturn coil comprising the steps of:
forming a base structure having a substrate (10) and a base layer (11, 44) formed in a given area on a topside of said substrate, the topside of said base layer having a substantially predetermined gradient (θ) against the topside of a substrate (10);
forming a loop-shaped laminate (15, 45) on said substrate (10) and said base layer (11, 44), said laminate (15, 45) comprising a plurality of conducting layers (14a-14d, 47a-47d) for coil and insulating layers (13a-13d, 46a-46d) for coil laminated alternately, having a space (A) of discontinuity of said base layer (11, 44) and a part of said laminate (15, 45) on said base layer (11, 44) having substantially the same gradient against another part of said laminate (15, 45) as said base layer (11, 44) against said substrate (10);
removing upper portion of a pair of discontinued end sections of said loop-shaped laminate (15, 45) formed on said base layer (11, 44) so as to reveal an end face of said each conducting layer (14a-14d, 47a-47d) and said each insulating layer (13a-13d, 46a-46d); and
mounting electrically conductive members (19a-19d, 61a-61d) between the revealed end faces of said individual conducting layers in each discontinued end section of said loop-shaped laminate (15, 45) to complete a multiturn coil.

2. A method as claimed in claim 1, wherein in said removing step the upper portion of each discontinued end section of said loop-shaped laminate (15, 45) on said base layer (11, 44) is removed to be substantially parallel to the topside of said substrate (10).

3. A method as claimed in claim 2,
further comprising another step of forming an insulating layer (16, 48) for covering thick enough to protrude above the topside of said laminate (15, 45) on and inside said loop-shaped laminate (15, 45) before said removing step,
wherein in said removing step said insulating layer (16, 48) for covering formed between said both discontinued end sections is removed together with the upper portion of each discontinued end section of said loop-shaped laminate (15, 45) is removed so as to be substantially parallel to the topside of said substrate (10) and said conductor members (19a-19c, 61a-61c) are supported by said insulating layer (16, 48) for covering at a position between the discontinued end sections of said loop-shaped laminate (15, 45).

4. A method as claimed in claim 1, wherein said multiturn coil is one for use in a film magnetic head.

5. A method as claimed in claim 1, the topside of said base layer (11) as an inclined plane.

6. A method as claimed in claim 5, wherein angle of inclination (θ) of the inclined plane of said base layer (11) is not more than 45°.

7. A method as claimed in claim 1, wherein the topside of said base layer (44) is inclined and stepped.

8. A method as claimed in claim 7, wherein individual step length (ℓ_1, ℓ_2, ℓ_3) are not smaller than the thicknesses of the respective conducting layers (41, 42, 43) of said laminate (45).

Fig. 1A Prior Art

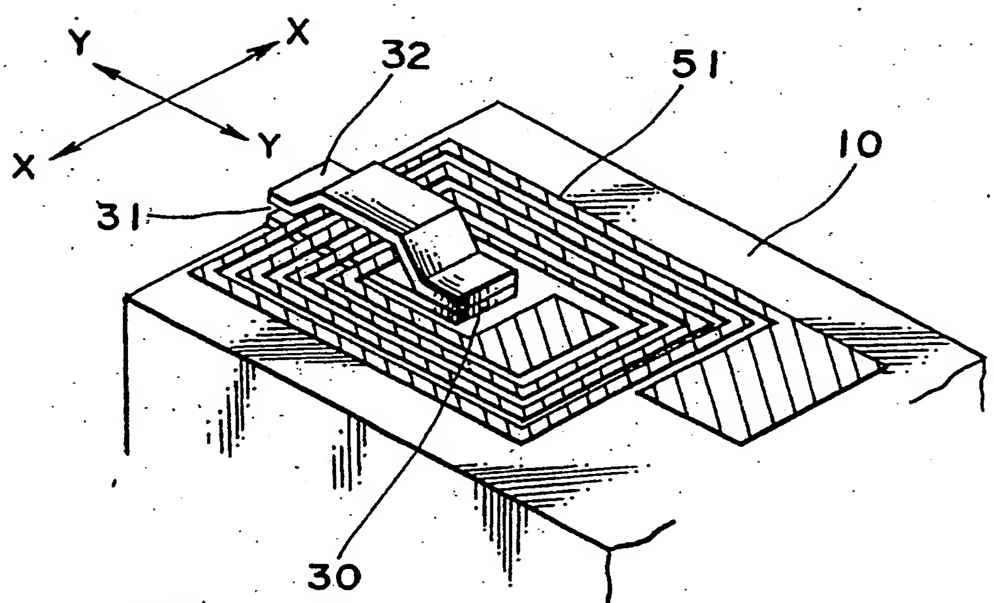


Fig. 1B Prior Art

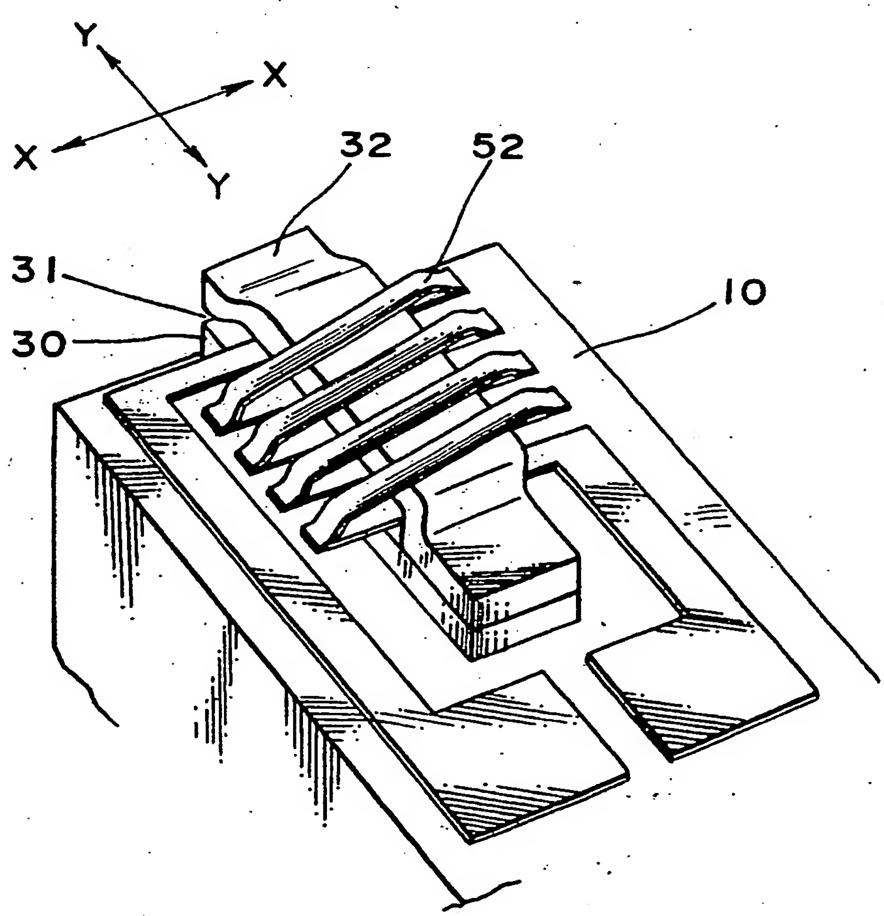


Fig. 1C
Prior Art

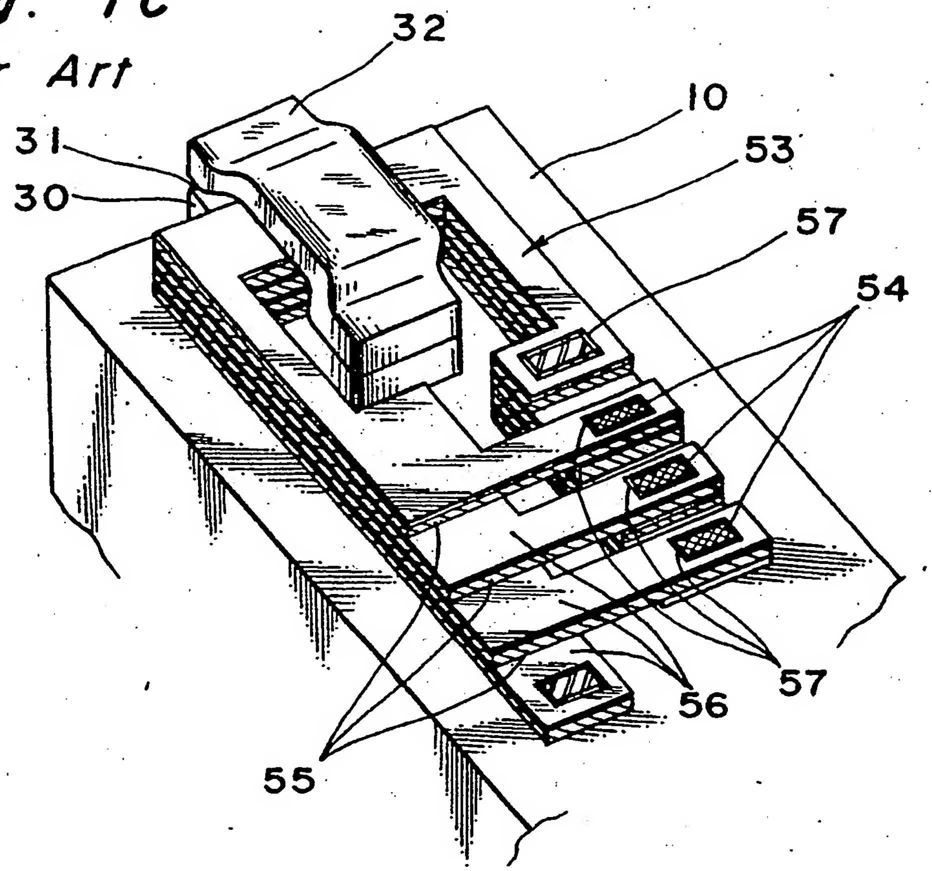
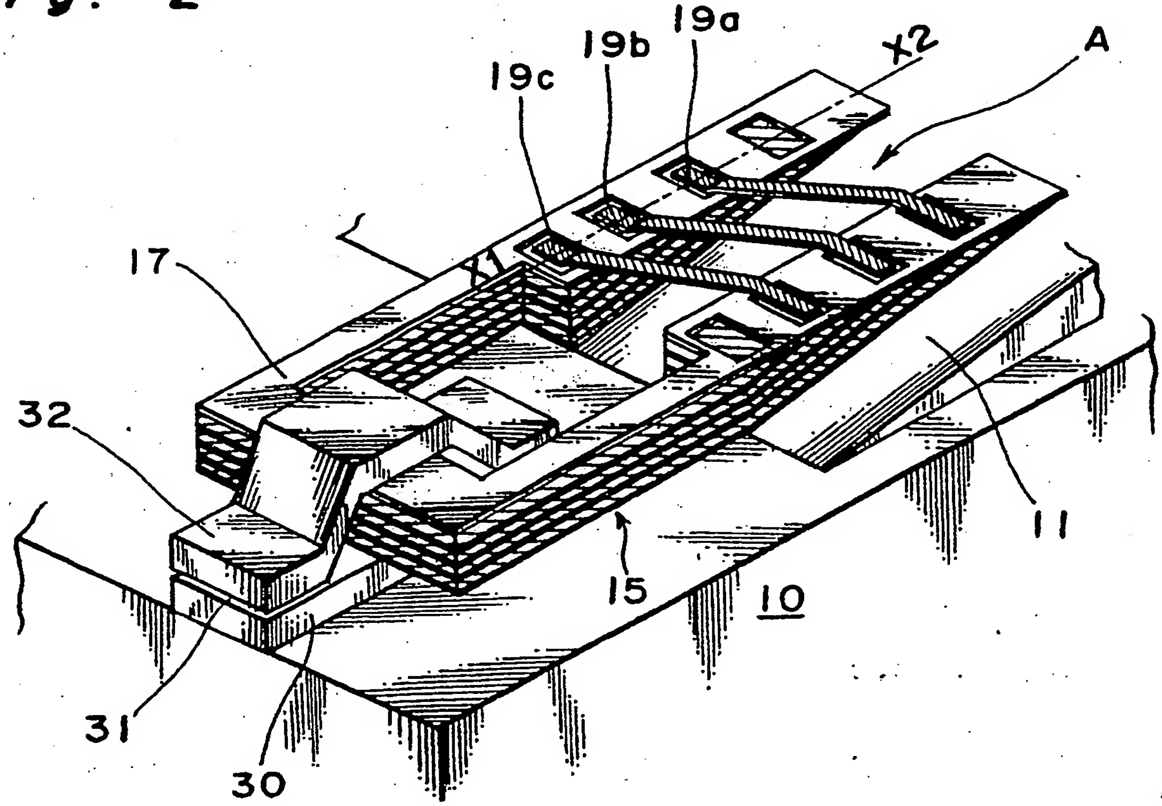


Fig. 2



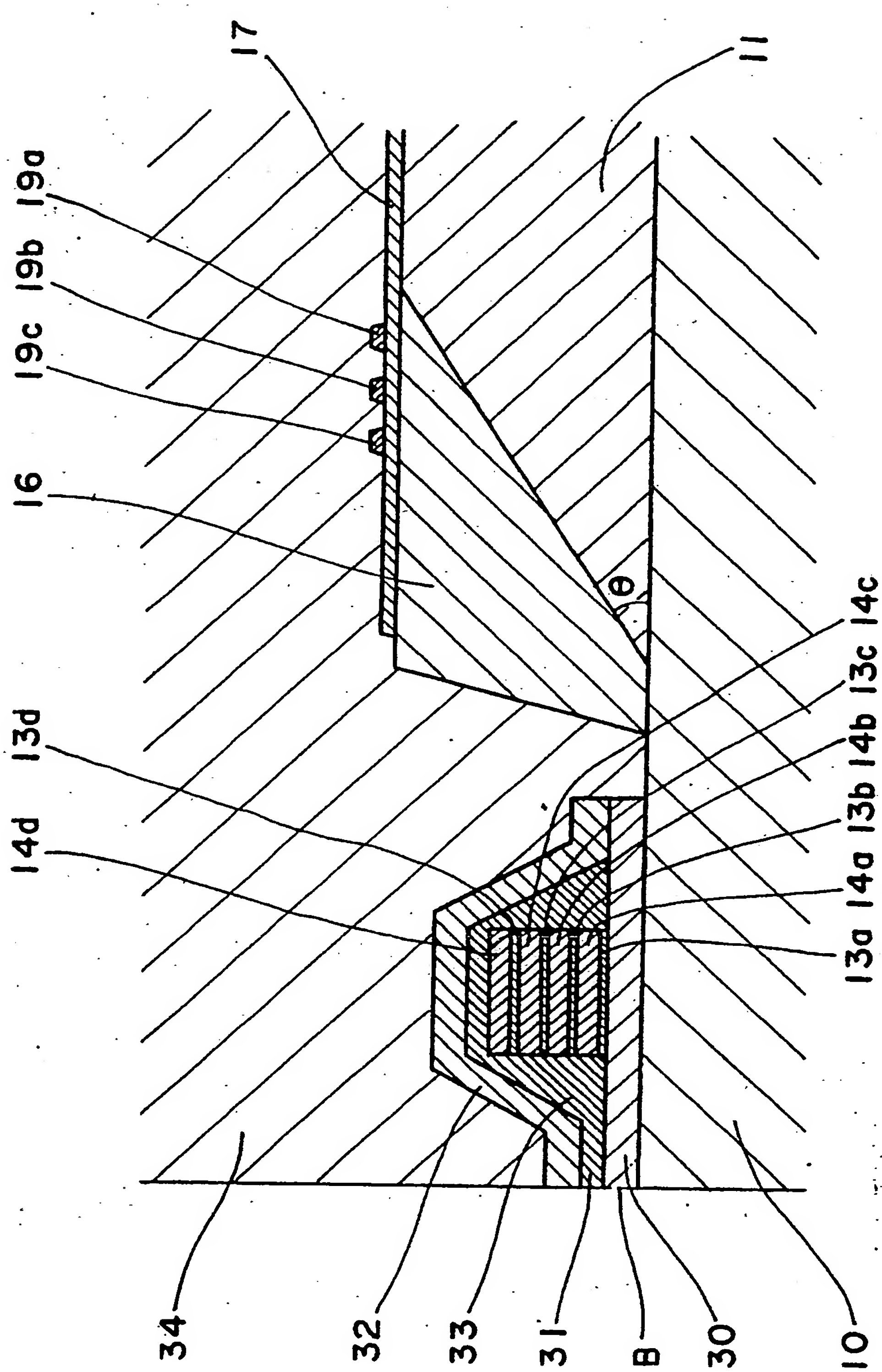

17
11
19a
19b
19c
16
θ
13d
14c
13c
14b
13b
14d
14a
13a
34
32
33
31
B
30
10

Fig. 2A

Fig. 3 I

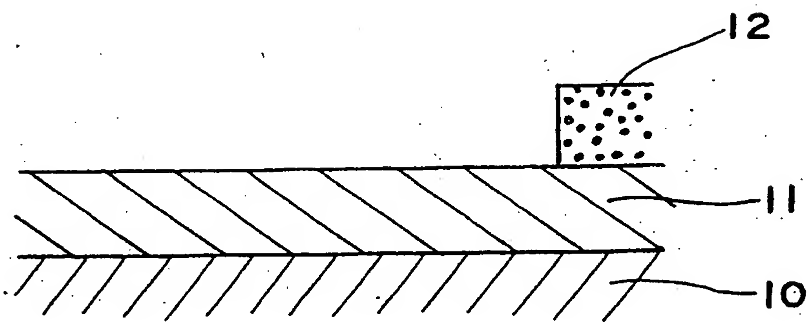


Fig. 3 II

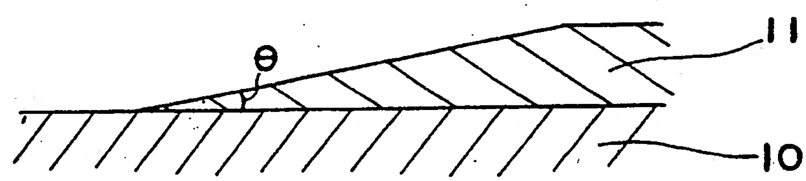


Fig. 3 III

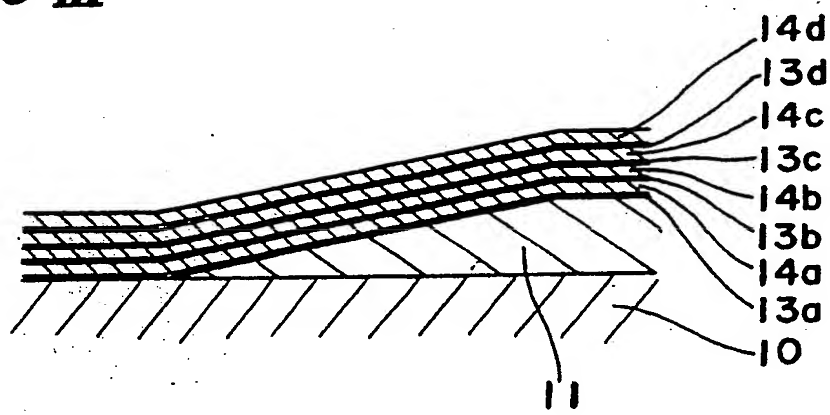


Fig. 3 IV

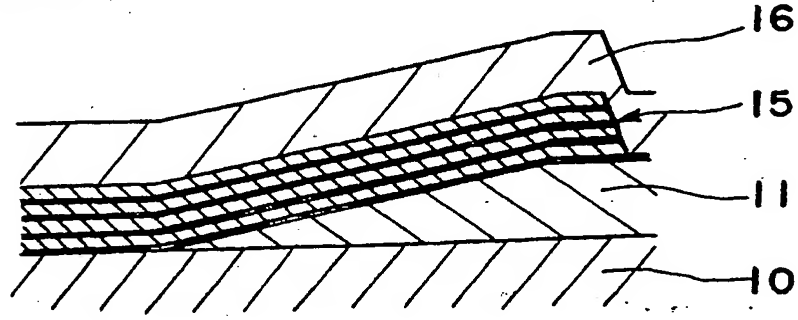


Fig. 3V

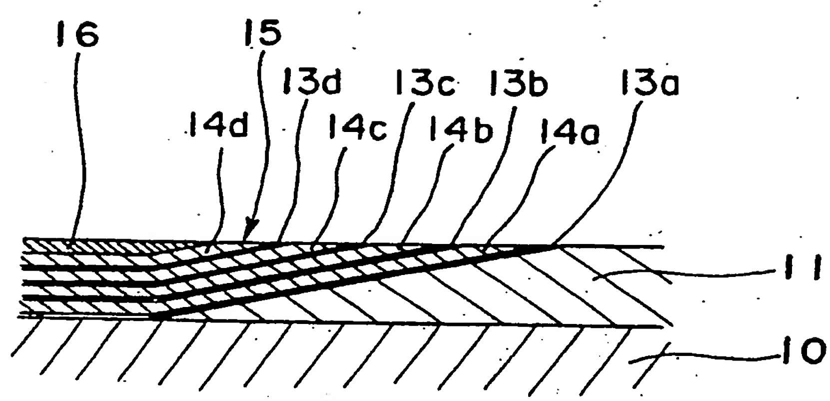


Fig. 3VI

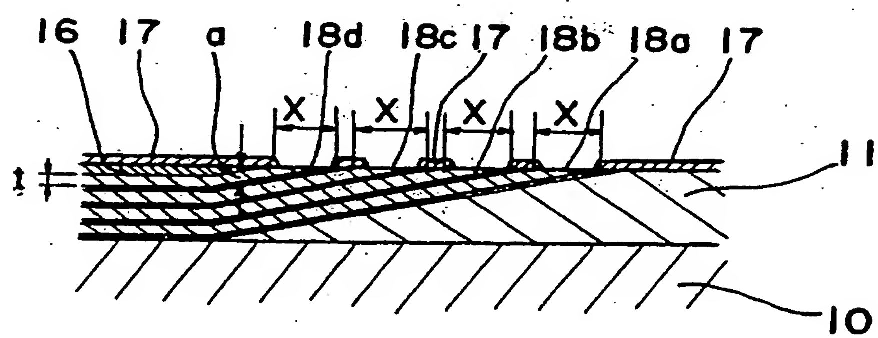


Fig. 3VII

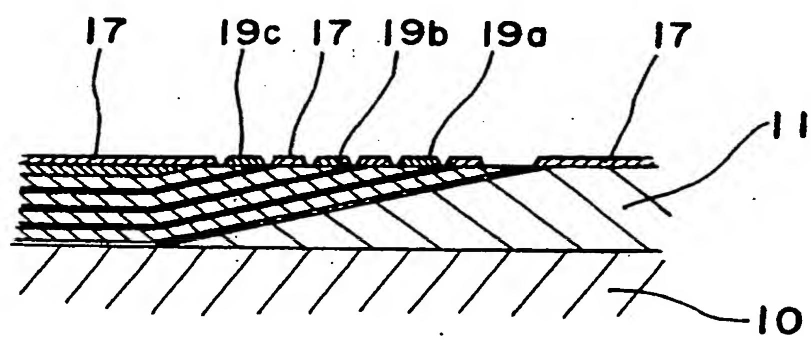


Fig. 4

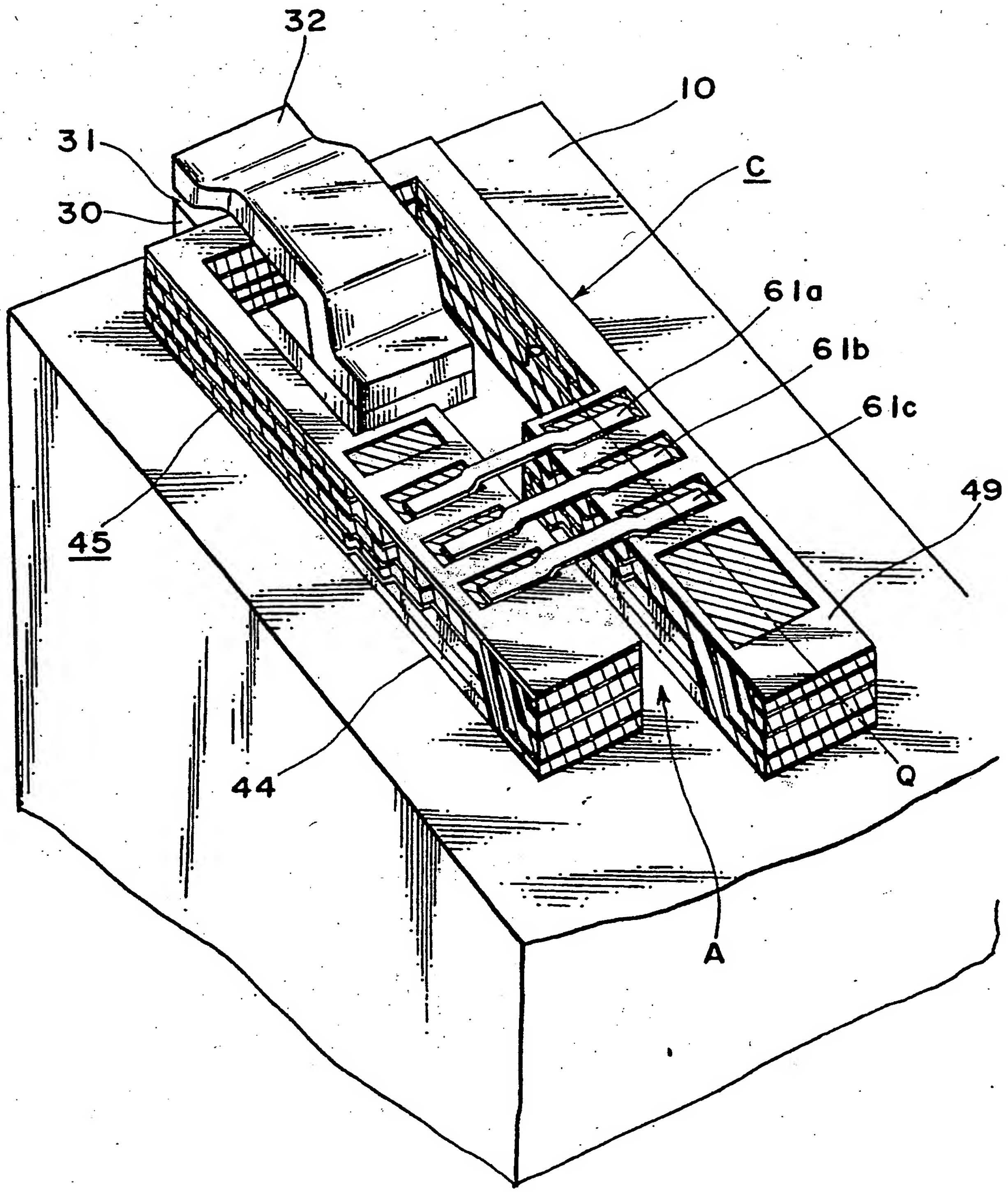
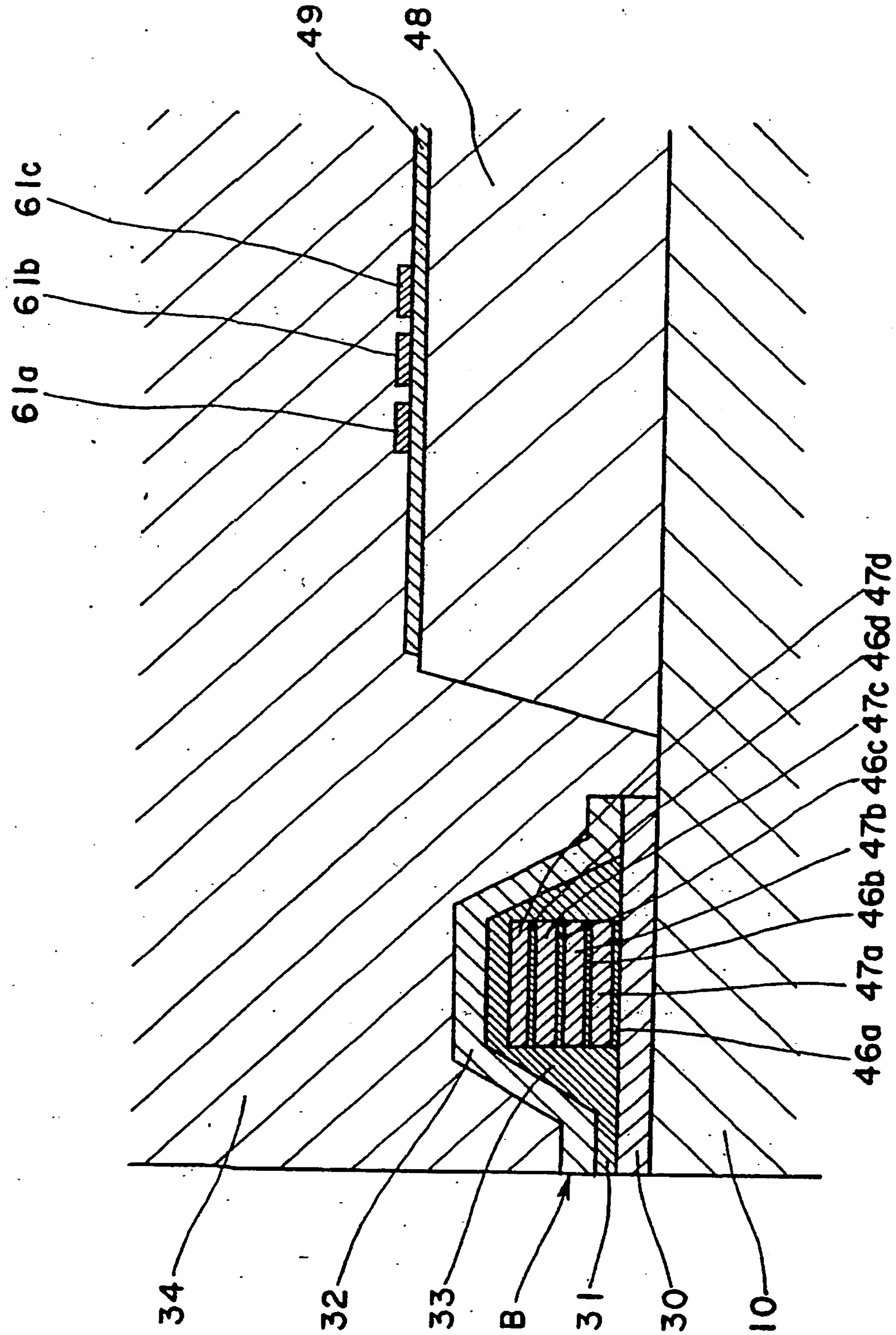


Fig. 4A



49
48
61c
61b
61a
46a
47a
46b
47b
46c
47c
46d
47d
34
32
33
B
31
30
10

Fig. 5I

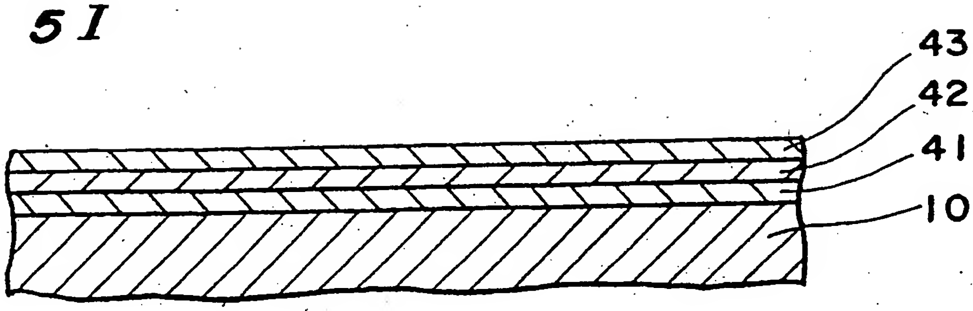


Fig. 5II

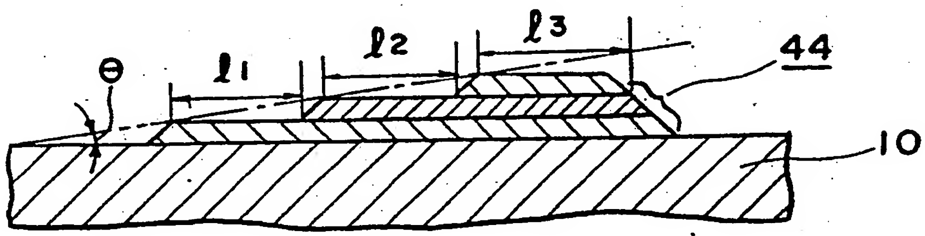


Fig. 5III

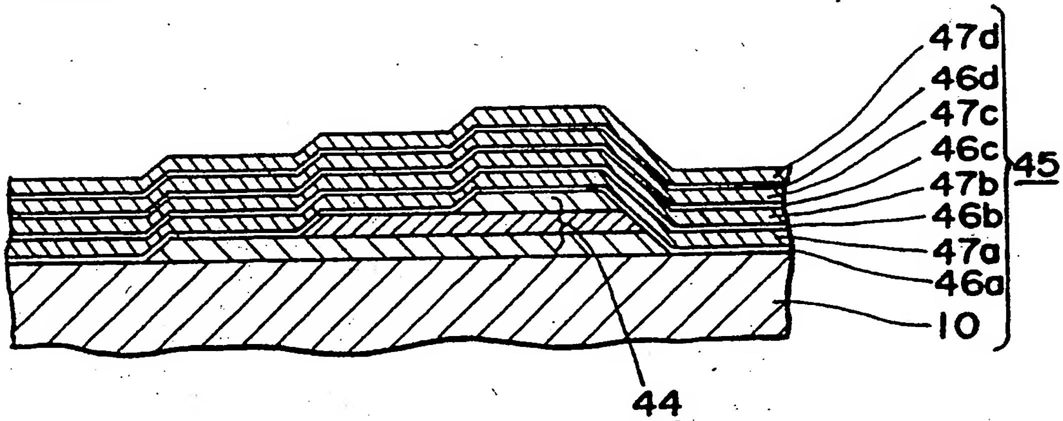


Fig. 5IV

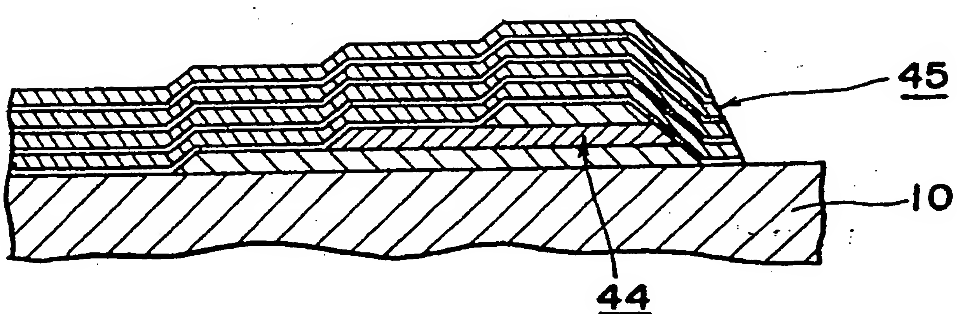


Fig. 5V

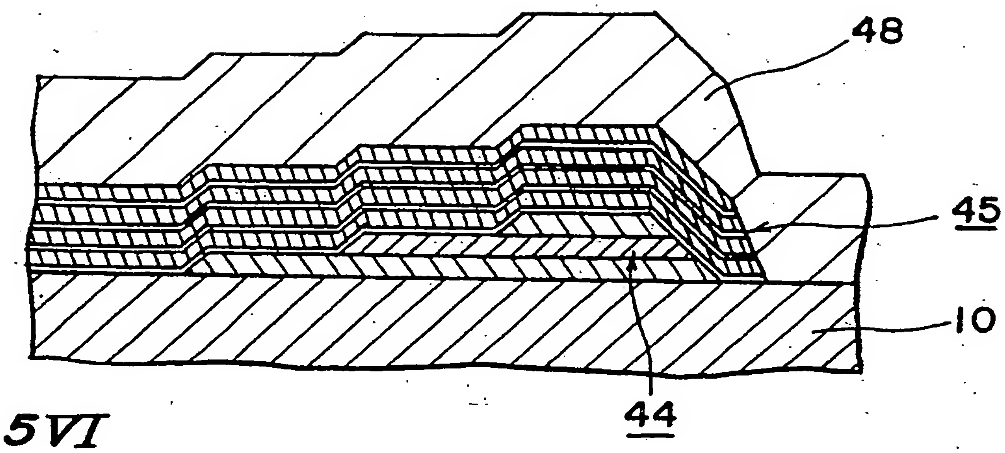


Fig. 5VI

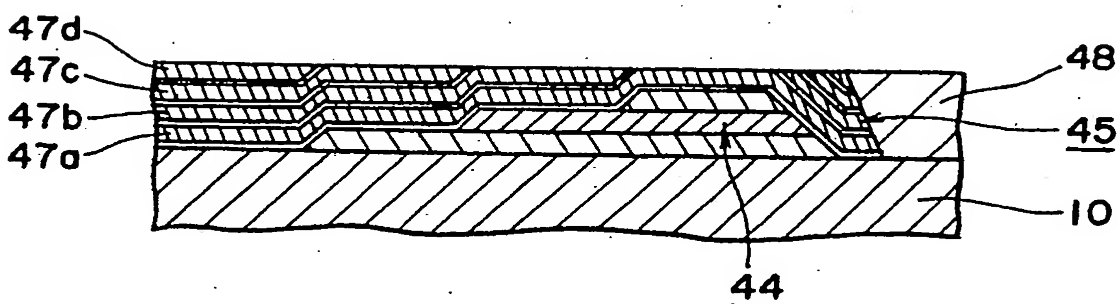


Fig. 5VII

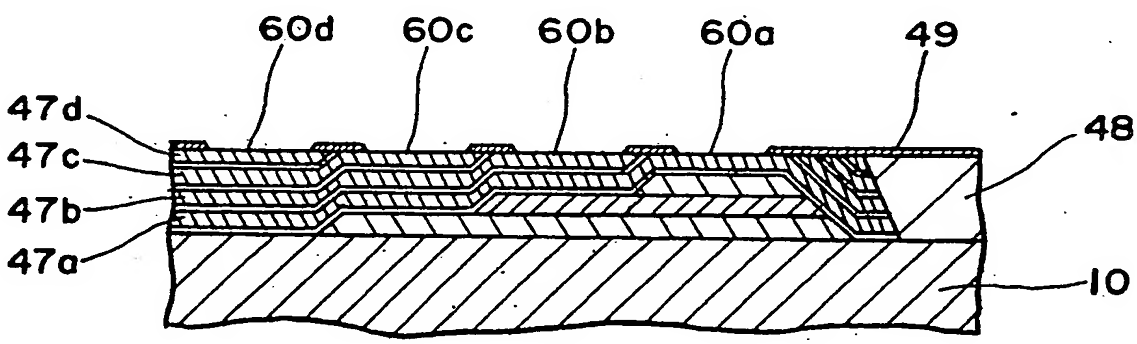


Fig. 5VIII